theoretical part: Knowledge Representation's techniques

Knowledge representation- Grado en Ingeniería Informática – 2019/2020

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1. What is Knowledge Representation?

Knowledge Representation in AI describes the representation of knowledge. Basically, it is a study of how the beliefs, intentions, and judgments of an intelligent agent can be expressed suitably for automated reasoning. One of the primary purposes of Knowledge Representation includes modeling intelligent behavior for an agent.

Knowledge Representation and Reasoning (KR, KRR) represents information from the real world for a computer to understand and then utilize this knowledge to solve complex real-life problems like communicating with human beings in natural language. Knowledge representation in AI is not just about storing data in a database, it allows a machine to learn from that knowledge and behave intelligently like a human being.

2. Types of Knowledge

- Declarative Knowledge – describes things, events, or processes, their attributes, and their relation to each other and expressed in a declarative sentence.

- Structural Knowledge – defines the relationship between concepts and objects.

- Procedural Knowledge – used for knowing how to do something, and which includes rules, strategies, procedures

- Meta Knowledge – describes knowledge about other types of Knowledge.

- Heuristic Knowledge – represents some expert knowledge in the field or subject.

3. Techniques of Knowledge Representation in AI
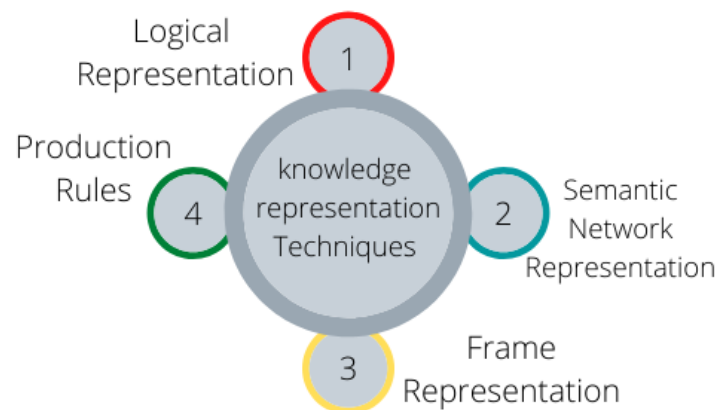
3.1. Logical Representation

Logical representation is a language with a certain way defined rules that deal with propositions and has no ambiguity in representation.
It represents a conclusion based on various conditions and it lays down some important communication rules.
Moreover, it consists on an exactly defined syntax and semantics, which support the sound inference.
Each sentence can be translated into logics by using syntax and semantics.

Syntax:
- It decides how we can construct legal sentences in logic.
- It determines which symbol we can use in knowledge representation.
- It shows how to write those symbols.

Semantics:
- they are the rules which we can interpret the sentence in the logic.
- They assign a meaning to each sentence.

Logical representation can be categorized into mainly **two logics**:
1. Propositional Logics
2. Predicate logics

Advantages:
- Logical representation helps to perform logical reasoning.
- This representation is the basis for the programming languages.

Disadvantages:
- Logical representations have some restrictions and are challenging to work with.
- This technique may not be very natural, and inference may not be very efficient.

3.2.   Semantic Network Representation

Semantic networks are alternative of predicate logic for knowledge representation.
In Semantic structure, we can represent our knowledge in the form of graphical structure, that consists of nodes which represent objects, and arcs which describe the relationship between those objects.
Semantic networks can categorize the object in different forms, and they can also link those objects.
Semantic networks are easy to understand, and they can be easily extended.
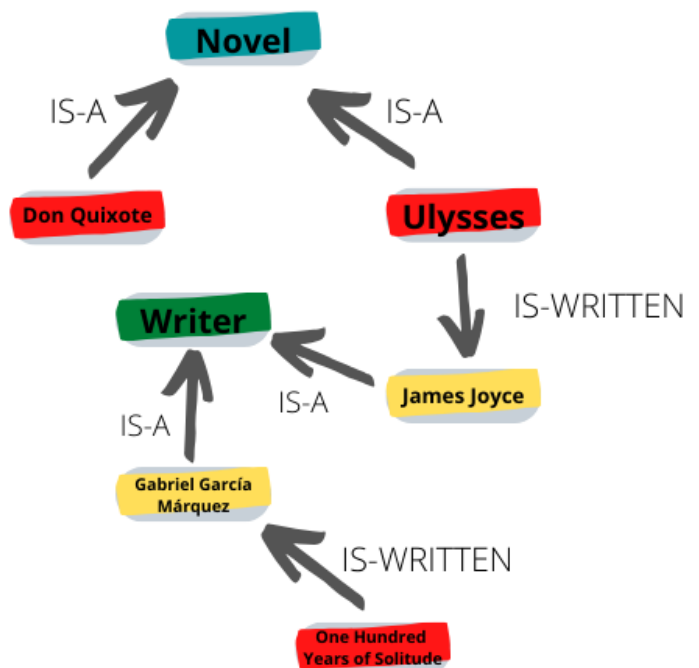
This representation consists of mainly two types of relations:

1. IS-A relation (Inheritance)
2. Kind-of-relation

3.2.1. Example:

Statements:
- Don Quixote is a Novel.
- One Hundred Years of Solitude is written by Gabriel García Márquez.
- Gabriel García Márquez is a writer.
- Ulysses is a Novel.
- Ulysses is written by James Joyce.
- James Joyce is a writer.

Advantages:

- Semantic networks are a natural representation of knowledge.
- They convey the meaning in a transparent way.
- These networks are simple and easy to understand.

Disadvantages:

- Semantic networks take more computational time at runtime.
- these are inadequate as they do not have any equivalent quantifiers.
- These networks are not intelligent, and they depend on the creator of the system.

3.3.   Frame Representation

The frame Representation is a record-type structure which consist on a collection of attributes and values to describe an entity, it consists of a collection of slots and slot values. These slots may be of any type and sizes. Slots have names and values which are called facets.

Advantages:

- the Frames make easier the programming by grouping the related data.
- It is easy to add slots for new attributes and relations.
- It is easy to include default data and to search for missing values.
- Frame representation is easy to understand and visualize.

Disadvantages:

- In frame system inference mechanism is not be easily processed.
- Inference mechanism cannot be smoothly proceeded by frame representation.
- It has a generic method.

3.4.   Production Rules

Production rules system consist of (condition, action) pairs which mean, "If condition, then action", the production rules system consists of three main parts:

- The set of production rules
- Working Memory
- The recognize-act-cycle

In production rules, agent checks for the condition and if the condition exists, then production rule fires and corresponding action is carried out.
The condition part of the rule determines which rule may be applied to a problem.
By noting this, the action part carries out the associated problem-solving steps. This complete process is called a recognize-act cycle.

The working memory contains the description of the current state of problems-solving and the rule can write knowledge to the working memory.
This knowledge match and may fire other rules.

If there is a new generated situation, then multiple production rules will be fired together, this is called conflict set.
In this situation, the agent needs to select a rule from these sets, and it is called a conflict resolution.

3.4.1. Example:

IF (soda machine is turned on AND the product is selected) THEN action (show the price)
IF (selected product AND paid AND drink available) THEN action (give drink).
IF (selected product AND paid AND drink unavailable) THEN action (give back money).
IF (selected product AND unpaid) THEN action (deselect product).

Advantages:

- The production rules are expressed in natural language.
- The production rules are highly modular, and they can be easily add, removed or modified.

Disadvantages:

- Production rule system does not exhibit any learning capabilities, as it does not store the result of the problem for the future uses.
- During the execution of the program, many rules may be active hence rule-based production systems are inefficient.

4. BIBLIOGRAPHY

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